

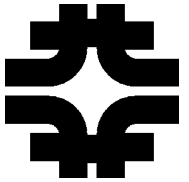
The NuMI Project CD-4 Review

**prepared by the
NuMI Project Team**

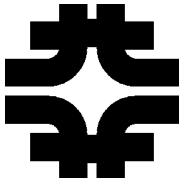
February 17, 2005



Outline



- Project Overview
- Presentation of CD-4 Commissioning Goals
- Plan for Transition to Operations

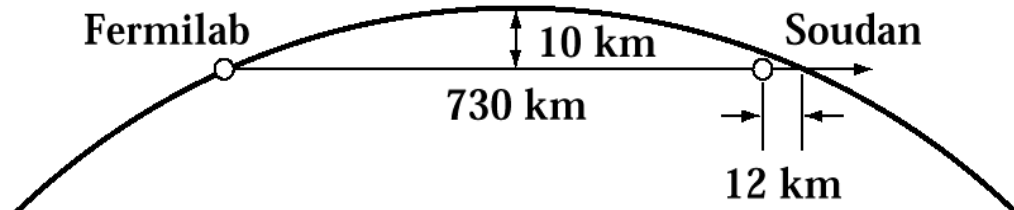
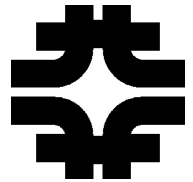


Project Overview

Gina Rameika



The MINOS Experiment



A 2-detector long-baseline
neutrino oscillation experiment
in a beam from Fermilab's
Main Injector

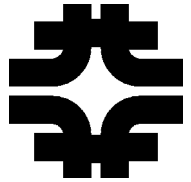
1st MINOS Collaboration Meeting : August 1994

MINOS Proposal Submitted : April 1995

Stage 1 Approval : June 1995

R&D & Conceptual Design Funds: FY97-98

Equipment Funds : FY99-05



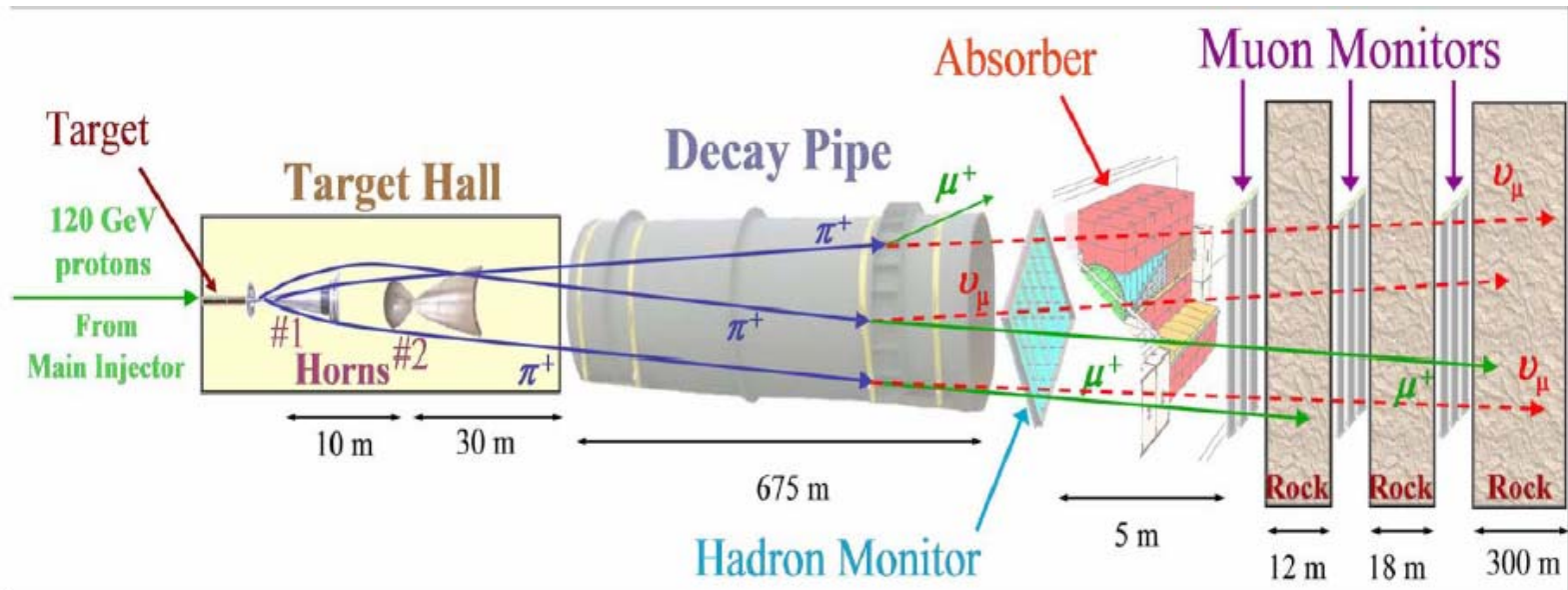
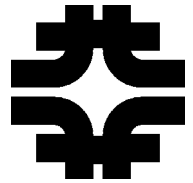
The NuMI Project

- 1.0 The NuMI Facility
 - 1.1 Technical Components
 - 1.2 Civil Construction
 - 1.3 Project Management
- 2.0 The MINOS Detectors
 - 2.1 Steel and Coils
 - 2.2 Scintillator Systems
 - 2.3 Electronics, Trigger and DAQ
 - 2.4 Far Detector Installation
 - 2.5 Near Detector Installation
 - 2.6 Project Management
- 3.0 Other Project costs
 - 3.1 Detector R&D
 - 3.2 Conceptual Design
 - 3.3 Cavern Construction
 - 3.4 Project Support
- CD-1 Approval of Mission Need
 - 3/17/1997
- CD-3a Start Limited Construction
 - 2/23/1999
- CD-2 Approve Baselines
 - 2/12/1999
- CD-3b Continue Construction
 - 5/21/1999
- CD-4 Start Operations
 - 3/2005

CD-1 → CD-4 : 8 years
\$171M authorized TPC



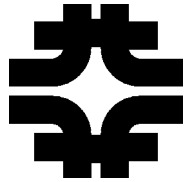
WBS 1.1 Technical Components



- 120 GeV protons, 4×10^{13} ppp, 1.8 sec cycle time, matched to MI emittance
- 1 interaction length graphite target
- Two focusing horns operated at 200 kAmp
- 7 kton steel shielding in target hall
- 2 meter diameter decay pipe, operated at < 1 Torr
- 9×9 10 cm-Pixel hadron monitor
- 1 kiloton hadron absorber with aluminum core
- 3 muon monitor stations



WBS 1.1.1 Primary Beam



MI-NuMI Stub transport

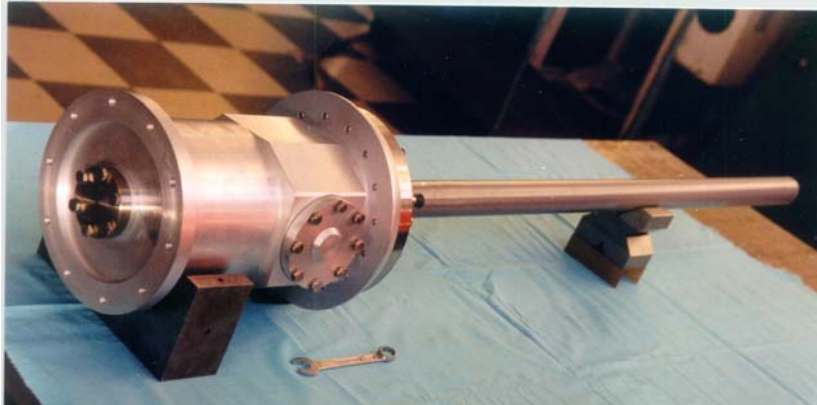
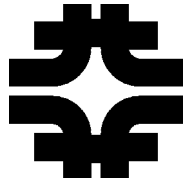


Pre-Target area





WBS 1.1.2 Neutrino Beam Devices



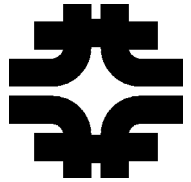
NuMI target assembly (upper)
Graphite target (lower)



DS end of Horn 1 in Target Chase



WBS 1.1.3 Power Supply System



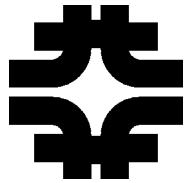
Target Hall
Power Supply Room



Horn stripline



WBS 1.1.4 Decay Pipe and Hadron Absorber



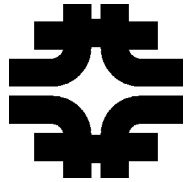
Decay Pipe Installation



DS Decay pipe window and completed absorber



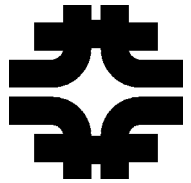
WBS 1.1.5 Neutrino Beam Monitoring



UTA Muon Monitor

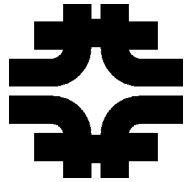


WBS 1.1.6 Alignment Systems





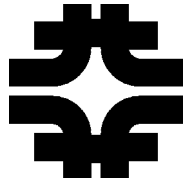
WBS 1.1.7 Water, Vacuum & Gas Systems



RAW (RadioActive Water) skids in the RAW room next to the Target hall



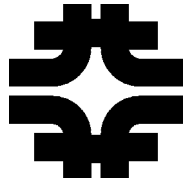
WBS 1.2 Facility Construction



- Scope
 - A 66 meter long lined carrier tunnel starting at the MI-NuMI stub
 - A 58 meter long unlined carrier tunnel
 - Pre-target/Target enclosure
 - MI-65 and MINOS Service Buildings and shafts
 - A 675 meter Decay Tunnel
 - Hadron Absorber Hall, Access Tunnel with Muon Alcoves
 - Near Experimental Hall, 30 meters long

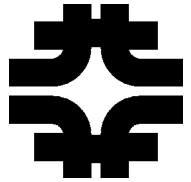


WBS 1.2 Civil Construction





Two Service Buildings



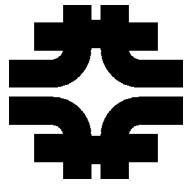
MI-65

MINOS Service Building





Two Shafts



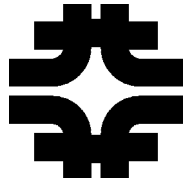
MI-65

MINOS

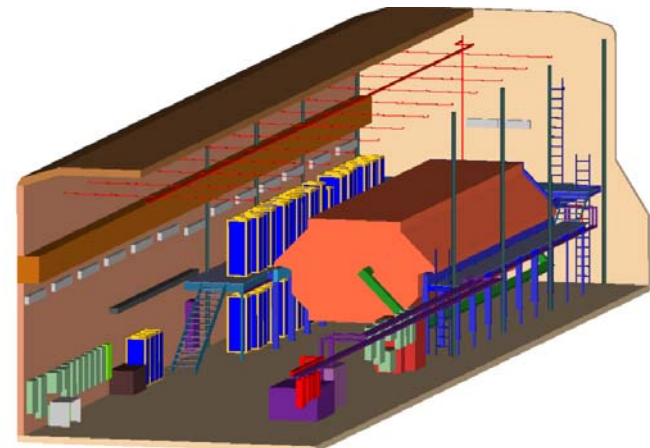
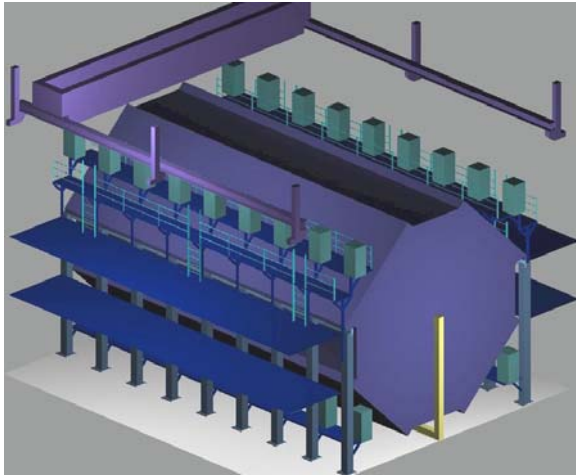




WBS 2.0 The MINOS Detectors

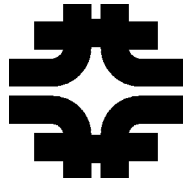


- Far Detector (Soudan Underground Lab)
 - 8m Octagonal Tracking Calorimeter
 - 2 sections, 15m each
 - 486 planes of steel & scintillator
 - 95,000 scintillator strips - 23K channels
 - 2 sided readout
 - 8 fold multiplexing
 - **5.4 kT total mass**
- Near Detector (MINOS Hall - FNAL)
 - 3.8 x 4.8m “octagonal” steel & scintillator tracking calorimeter
 - Same basic construction, sampling & response as the far detector
 - 282 planes of steel
 - 153 planes of scintillator - 9200 channels
 - 120 fully instrumented calorimeter
 - 33 4-fold multiplexed spectrometer
 - **980 ton total mass**





WBS 3.3 Soudan Cavern Construction



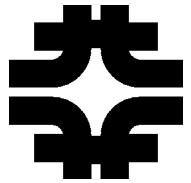
Begin Cavern Construction :
October 1999



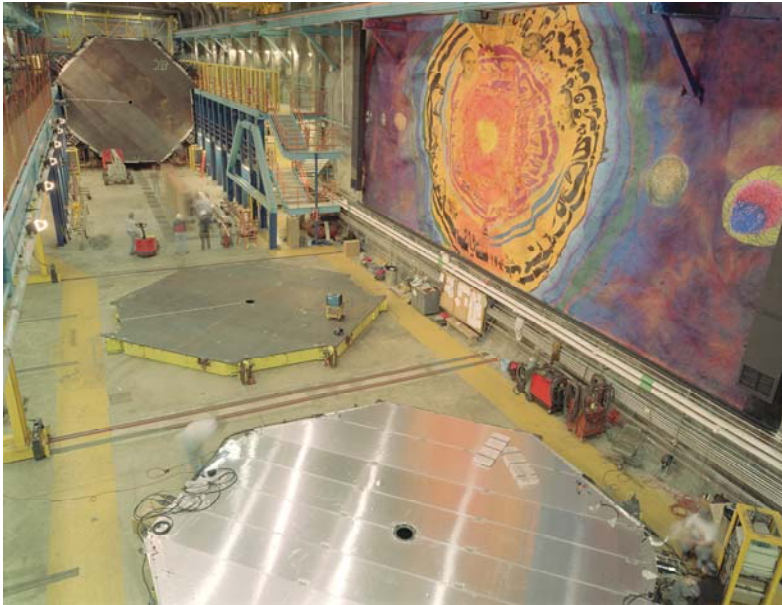
February 17, 2005



WBS 2.4 MINOS Far Detector Installation



Building a ship in a bottle



Installation begins July 2001

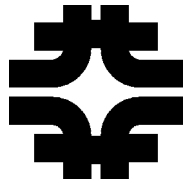


Construction completes July 2003

Two magnetized
Super-modules
operate routinely
collecting Atmospheric
Neutrino Physics Data



WBS 2.5 Near Detector Installation



First plane (281) installed March 31, 2004



Installed **5 spectrometer planes per day**;

Each day ending with an instrumented plane which was commissioned in the evening by collaborators



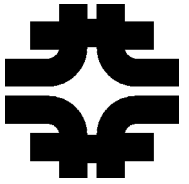
Installed **3 calorimeter planes per day**;

Well choreographed team of plane installers and cablers

3 planes commissioned evening

Last plane (0) installed August 11, 2004





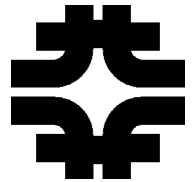
Commissioning Run

January 21-23, 2005

Bruce Baller



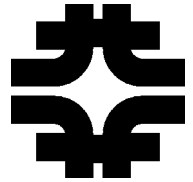
CD-4 Commissioning Goals



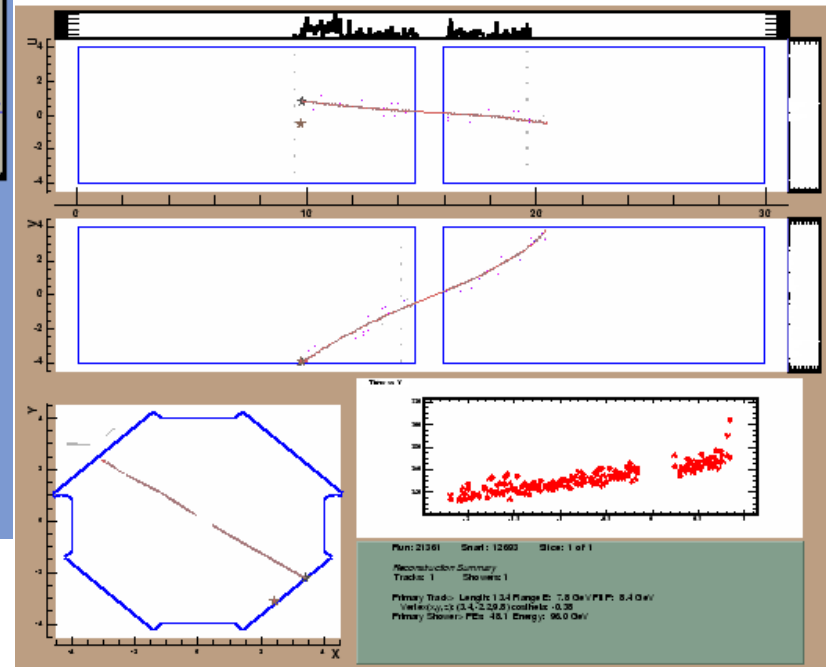
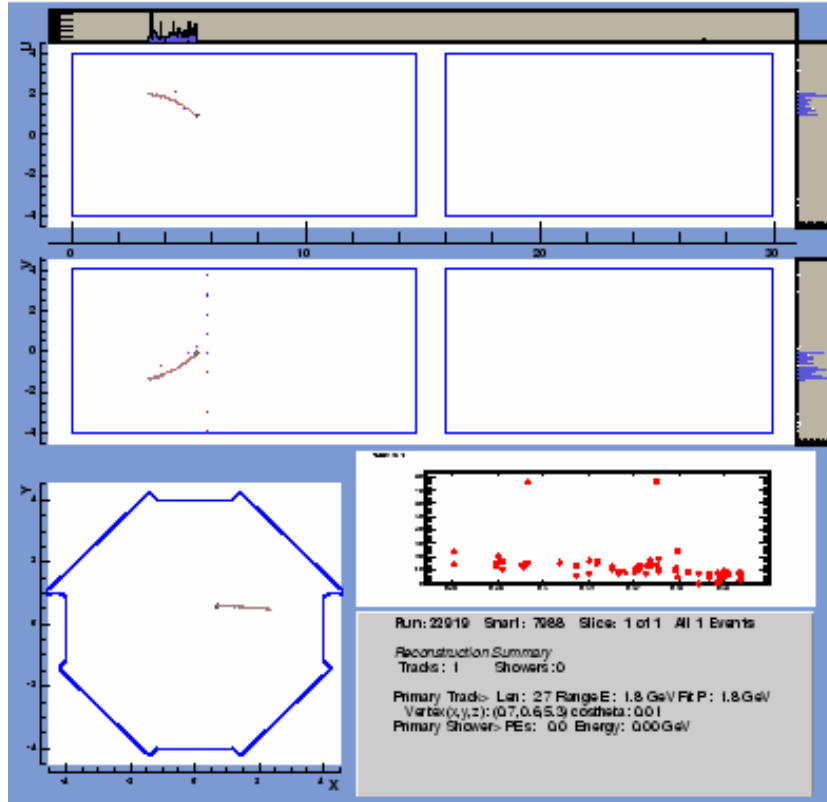
	Parameter	Measurement	Commissioning Goal
1	Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the target hall	Greater than 1×10^{12} 120 GeV protons per spill
2	Beam alignment	Transverse distributions of the proton beam and secondary beams	Proton direction established to within 1 mr of the known direction to the far detector in the Soudan mine
3	Neutrino beam energy	Near Detector event energy	low energy, 2-4 GeV
4	Cosmic ray muons detected in the MINOS Near Detector	Near Detector data read out through DAQ system	Majority of the 153 Near Detector planes sensitive to muons
5	Near Detector neutrino flux	Charged-current event rate in 1.5 ton fiducial region	Observe neutrinos produced in the Near Detector by the NuMI beam
6	Cosmic ray muons and atmospheric neutrinos detected in each of the two MINOS Far Detector Supermodules	Far Detector data read out through DAQ system	Majority of the 484 planes of the Far Detector sensitive to muons and atmospheric neutrinos



Cosmic Rays and Atmospheric Neutrinos in the Far Detector

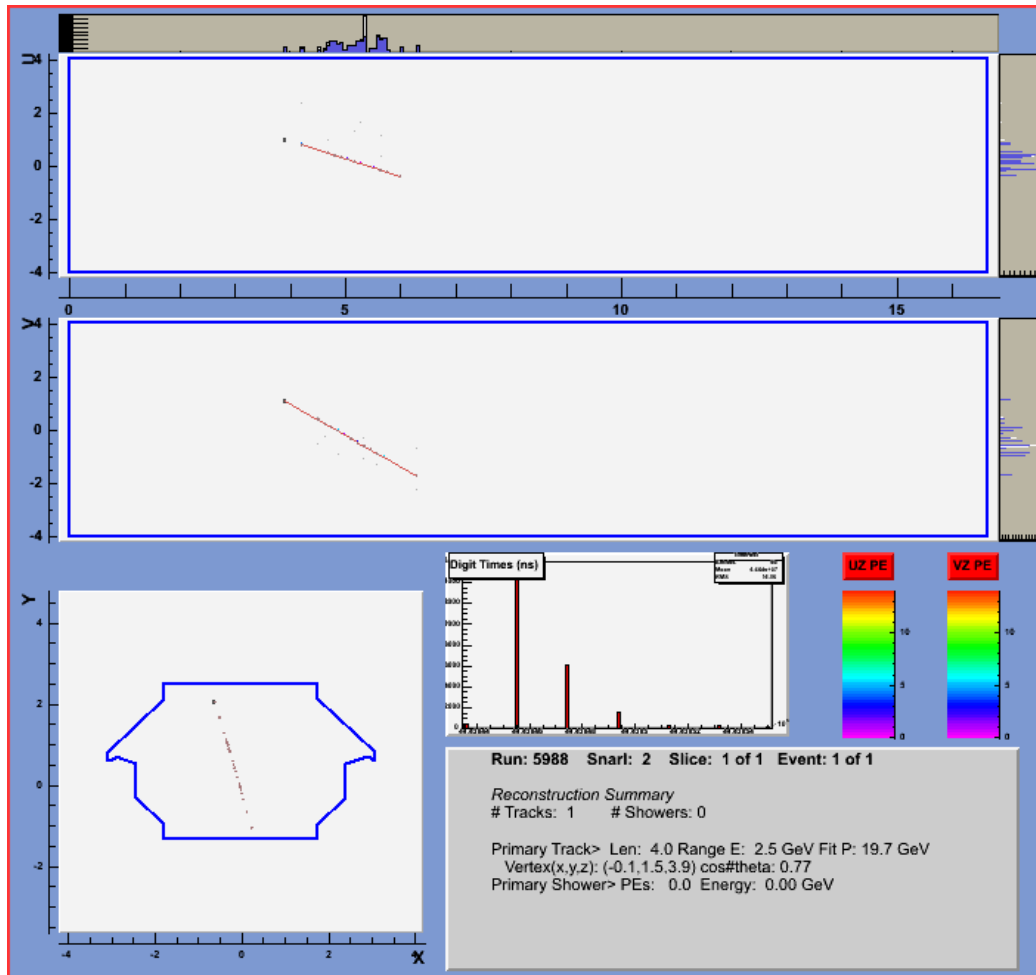
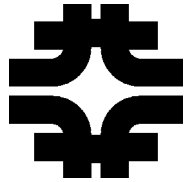


Goal 6 achieved





Cosmic Rays in the Near Detector



Goal 4 achieved



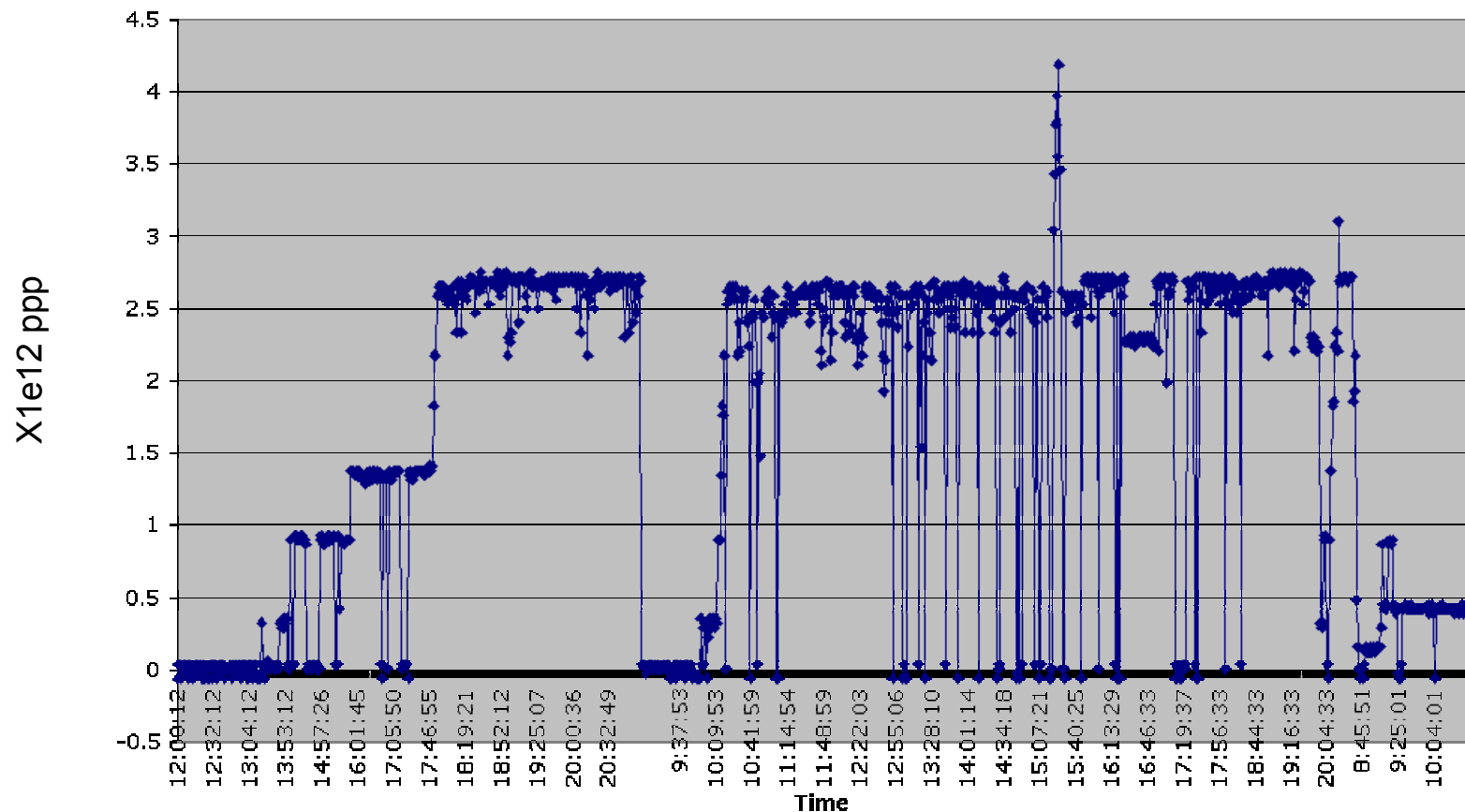
Proton Intensity > 1e12 ppp

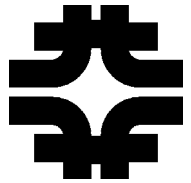


Goal 1 achieved

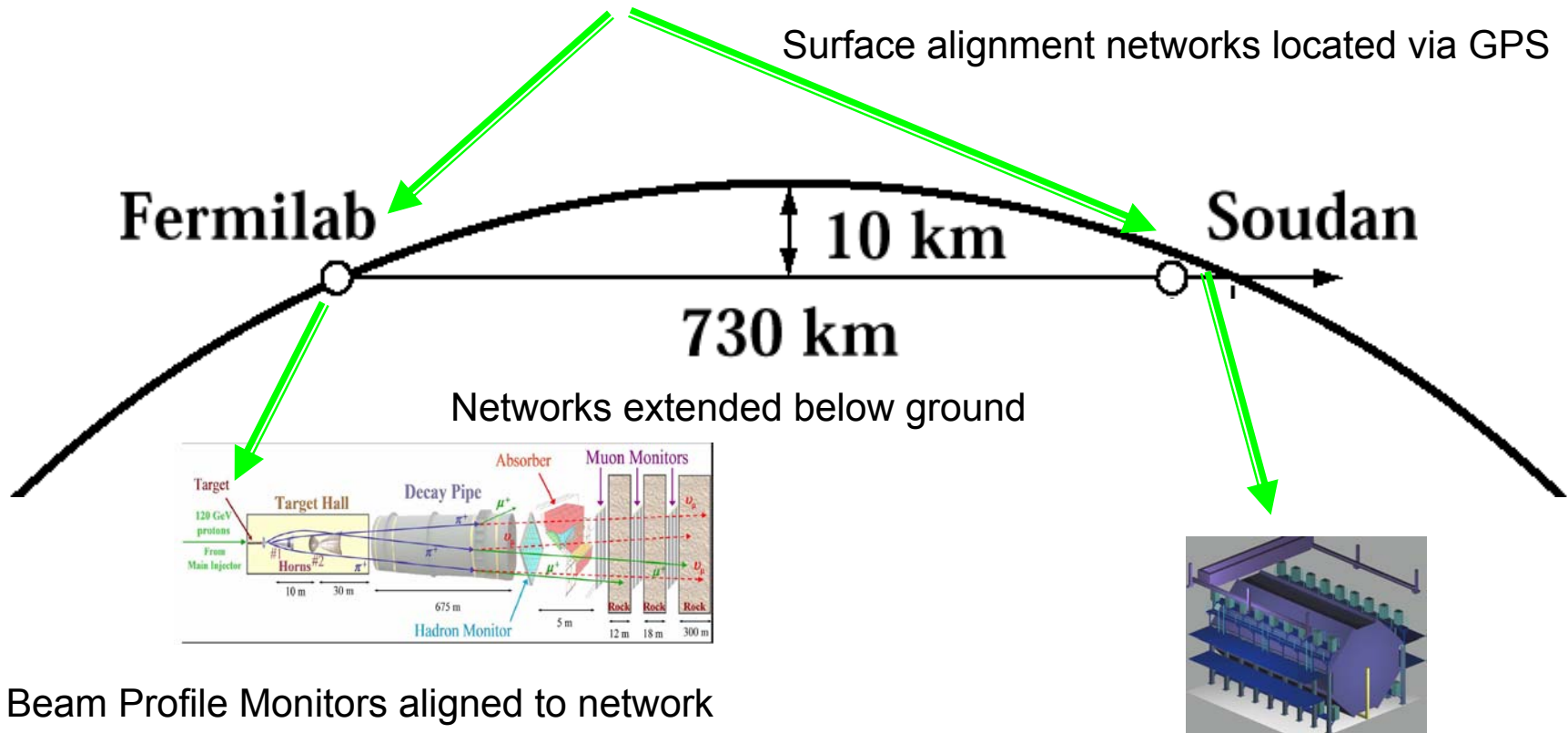
NuMI CD-4 Commissioning Run
Protons on Target

January 21-22, 2005





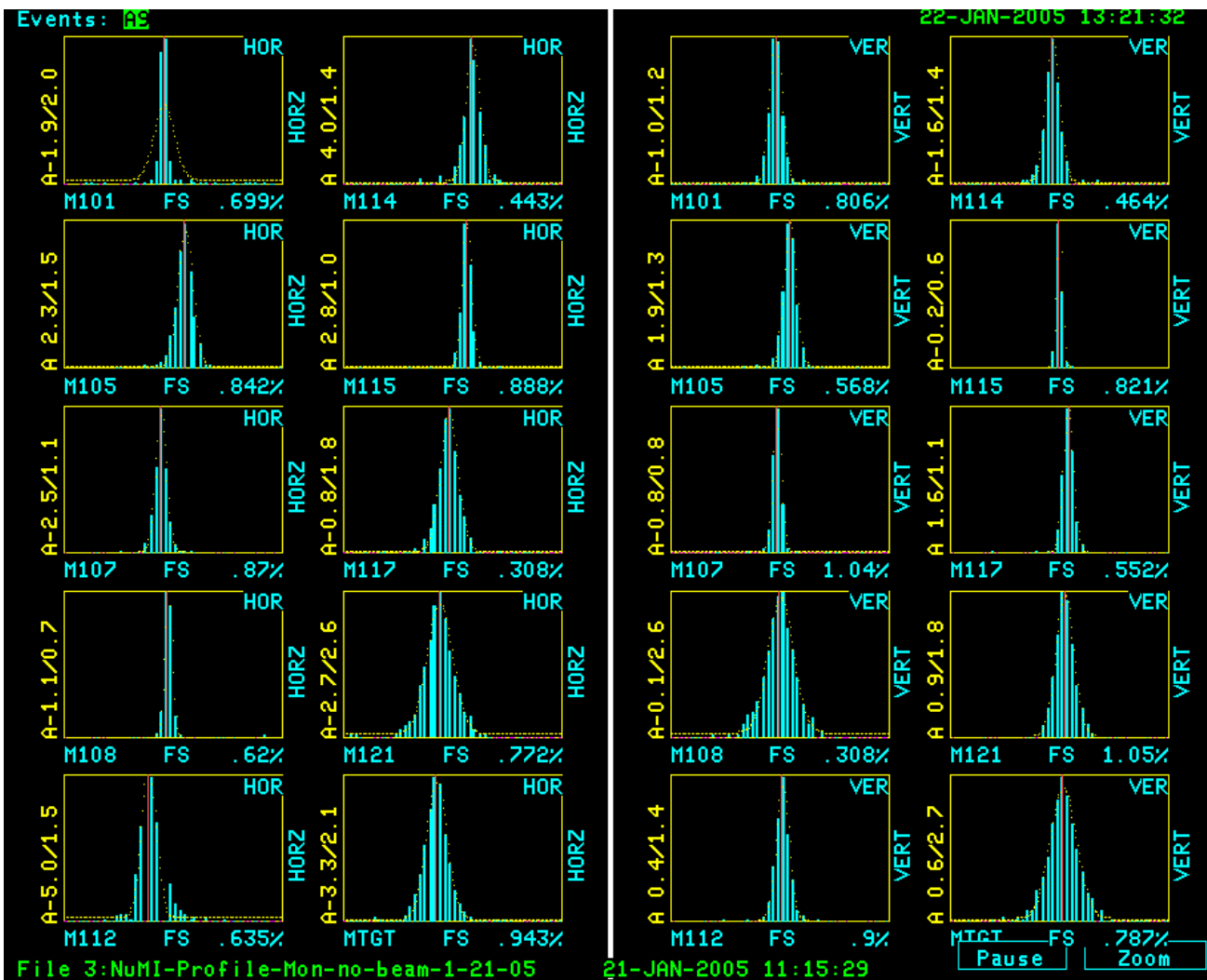
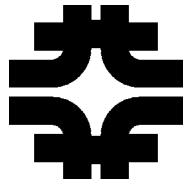
Goal 2 Achievement



Beam Profile Monitors aligned to network
Hadron Monitor aligned to network

**Goal 2 : Beam angle to Soudan = Beam centered on
Profile Monitors and Hadron Monitor**

Beam Profile Monitors

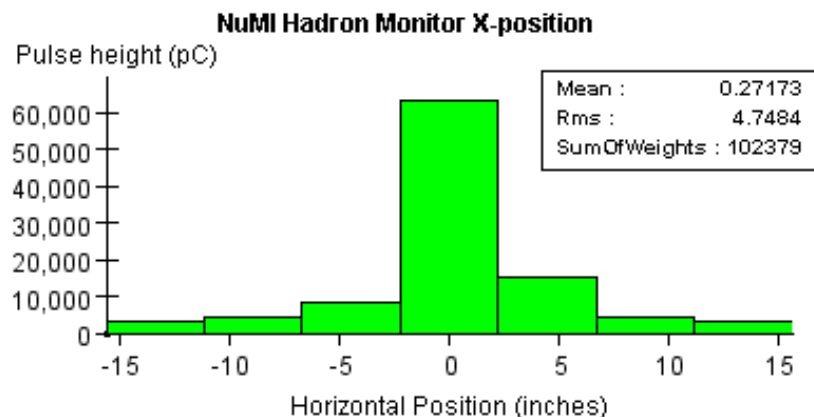


Beam centered on monitors in extraction region

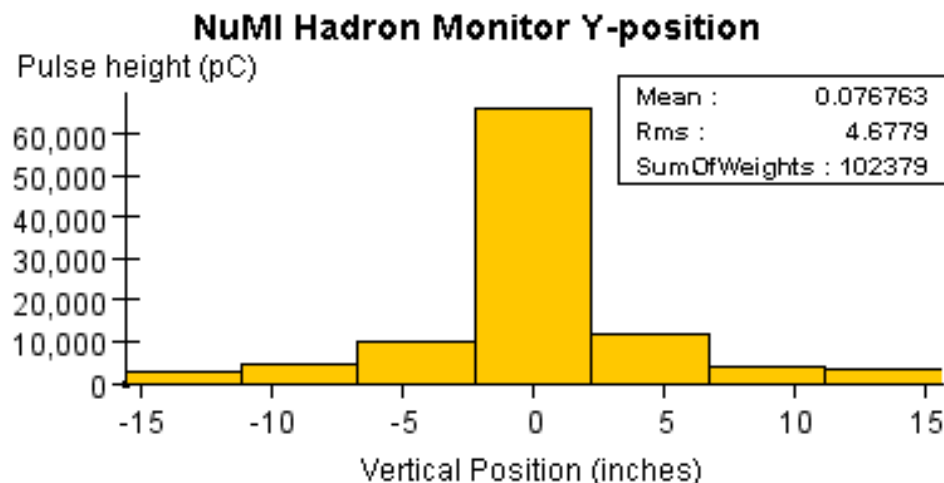
**Input to Goal 2:
Beam centered
on monitors in
Pre-Target**



Hadron Monitor Beam Profiles

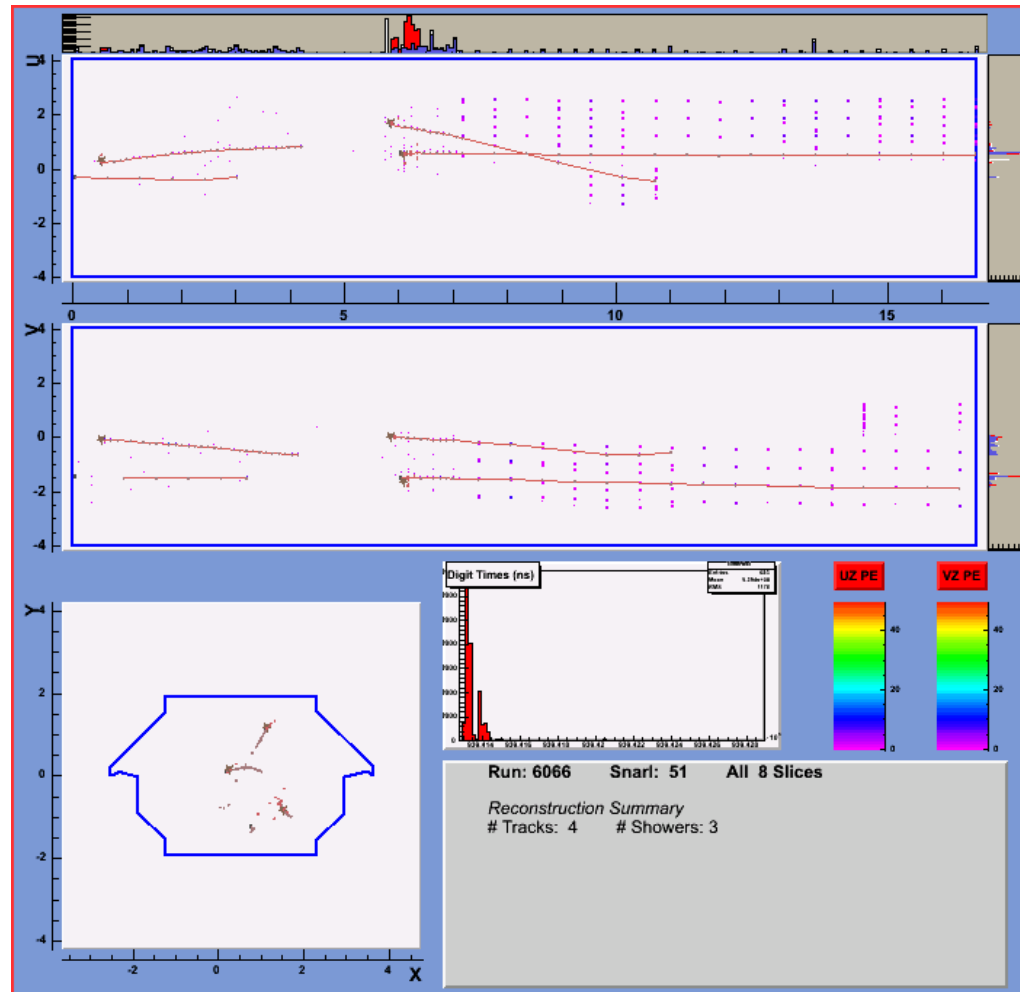
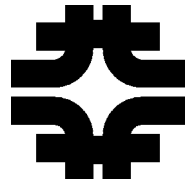


**Goal 2 Achieved:
Beam centered
on Hadron
Monitor in
Absorber Cavern**



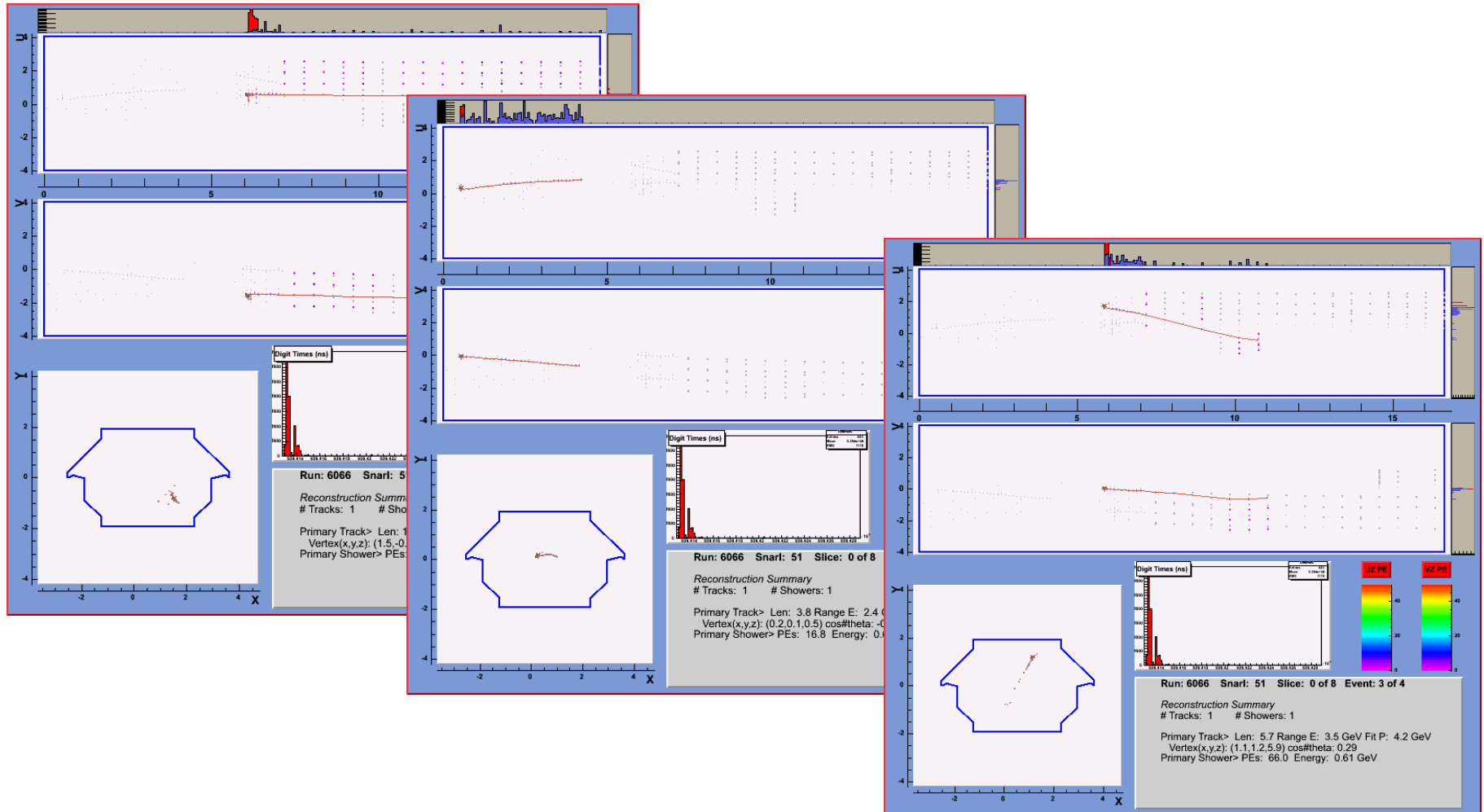
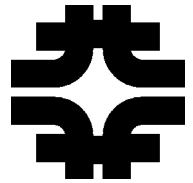


First Neutrinos in the Near Detector



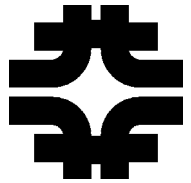


Near Detector Event “slicing”



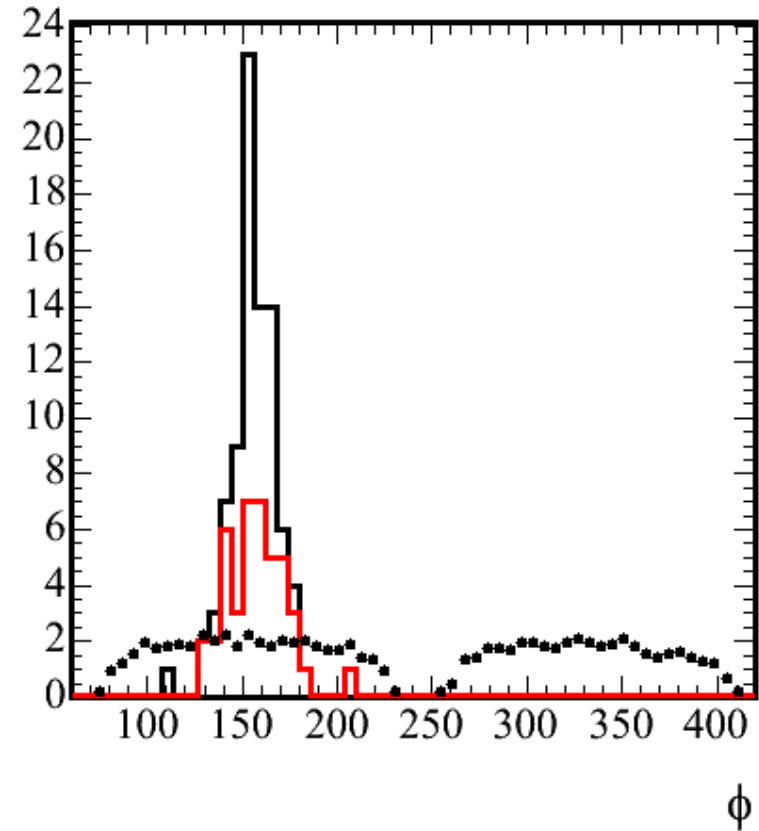
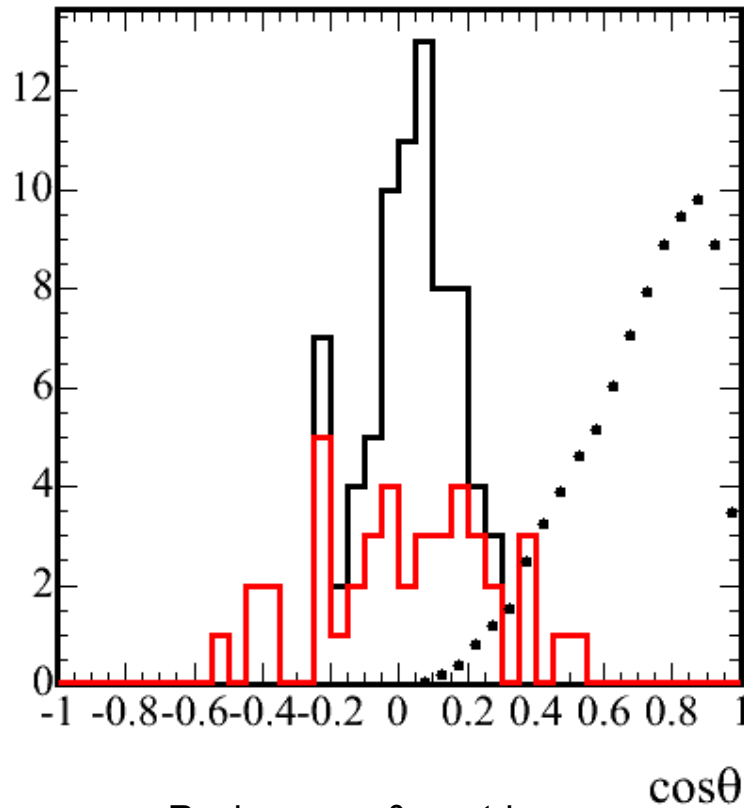


Neutrinos from the beam



Track $\cos\theta$

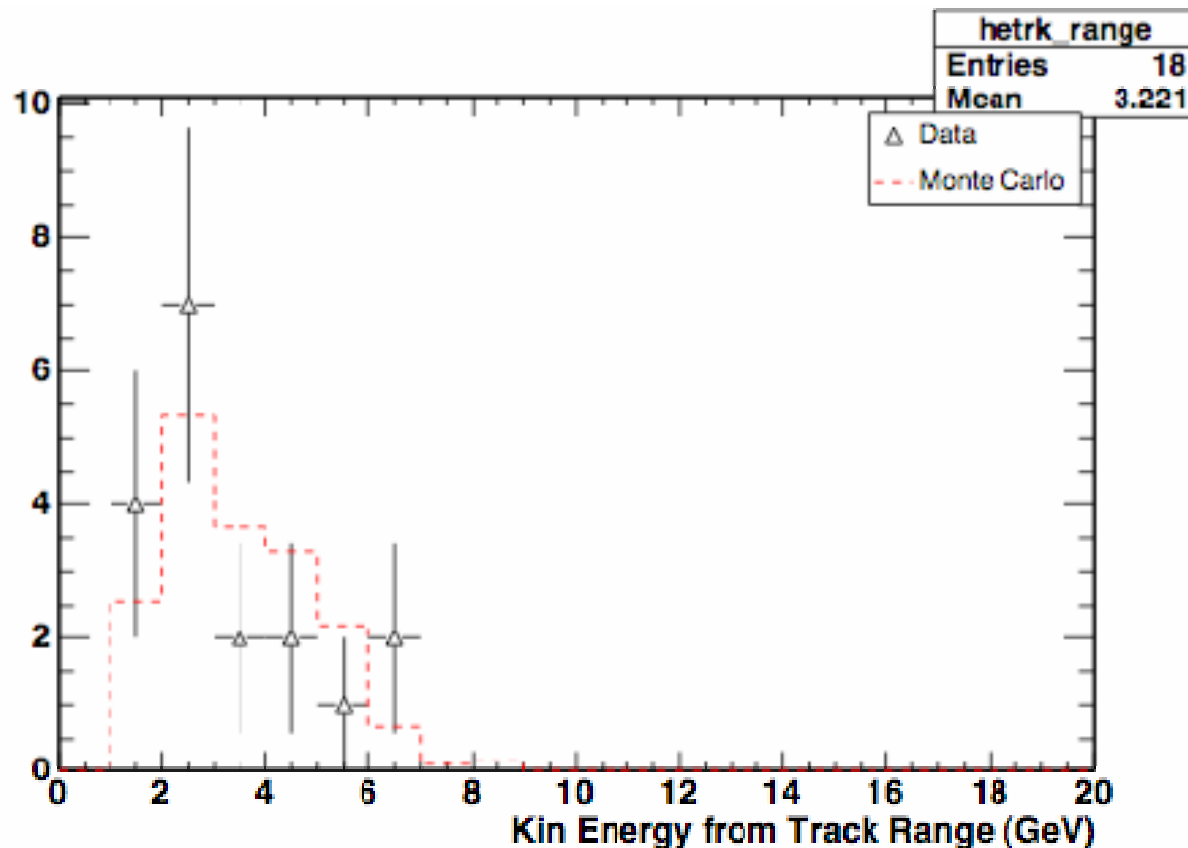
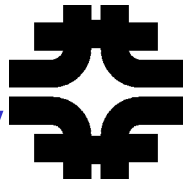
Track Azimuth



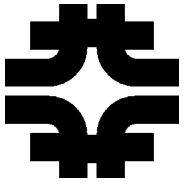
— Rock muons & neutrinos
— Contained neutrinos
... cosmics



Charged Current Muon Energy



Goal 3 achieved
Goal 5 achieved

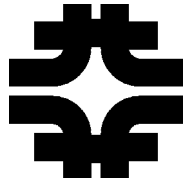


Transition to Operations

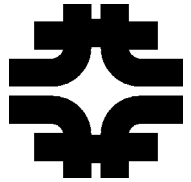
Greg Bock



NuMI Facility Transition to Operations



- Final Acceptance of facility from SBO subcontractor on 10-13-04
 - FESS accepted responsibility for plant equipment maintenance
 - NuMI Project accepted ownership of facility
- Transition from Project to Division Ownership
 - AD & PPD Building Managers worked with Project Floor Managers to understand facility and equipment
 - Operational access procedures and training developed by AD, PPD, & ESH Section
 - Response to alarms and notifications changing from Project personnel to responsible lab personnel



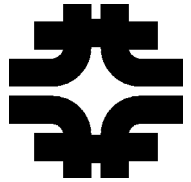
NuMI Beamline

Transition to Operations

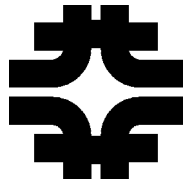
- Beam Operation (procedures, applications, control, maintenance) is equivalent to existing beams (e.g. MiniBooNE)
 - Use existing operations and support staff
 - Operations staff trained in NuMI specifics (e.g. Search and Secure)
 - Beam monitoring training on-going
 - Use standard FNAL beam components except UT-Austin profile monitors
 - Maintenance MOU for profile monitor in review
- Target Hall operation and maintenance procedures similar to MiniBooNE experience
 - Use existing MSD Target Hall Support staff with MiniBooNE experience
 - Staff also responsible for MiniBooNE
 - NuMI specific procedures in place



MINOS Experiment Transition to Operations



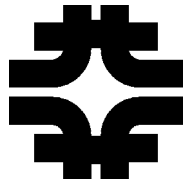
- **Soudan Laboratory**
 - Minecrew + visiting physicists underground Monday-Friday 7:30 am - 5:30 pm
 - Surface Building for evenings and weekends (CDMS)
 - Shift leaders' house for evenings and weekends (MINOS)
 - 24/7 on-call for access (driven by CDMS need)
- **Fermilab**
 - Wilson Hall 12th floor control room (no control room at Exp Hall)
 - Monitors and controls both Near and Far Detectors
 - 24/7 shifts when beam is operating
- **Remote Operation**
 - DAQ, trigger, light injection controllable from UK
- **MOU between Experiment and Fermilab**
 - Defines roles and responsibilities of Fermilab organizations and the collaborating institutions with equipment maintenance responsibilities



Cost Summary - TEC

WBS / Description		Total Estimated Cost	Actual Cost of Work Performed	Total Obligated incl RIP's
1.1	Technical Components	\$29,977	\$30,192	\$30,507
1.1.1	Extraction & Primary Beam	5,986	5,960	6,050
1.1.2	Neutrino Beam Devices	11,799	11,780	11,930
1.1.3	Power Supply System	5,480	5,486	5,495
1.1.4	Hadron Decay and Absorber	1,584	1,583	1,593
1.1.5	Neutrino Beam Monitoring	481	486	487
1.1.6	Alignment Systems	251	205	238
1.1.7	Water, Vacuum & Gas Systems	2,182	2,210	2,210
1.1.8	Installation and Integratation	2,153	2,419	2,440
1.1.9	Hadronic Hose (Close-out)	62	63	63
1.2	Facility Construction	\$74,652	\$74,586	\$74,586
1.3	Project Management	\$3,181	\$3,129	\$3,132
	Contingency	\$1,358		
1	Total Estimated Cost	\$109,168	\$107,907	\$108,225

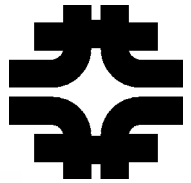
TEC - Obligation
= \$943K



Cost Summary - OPC

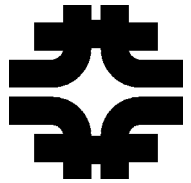
WBS / Description		Total Estimated Cost	Actual Cost of Work Performed	Total Obligated incl RIP's
2	MINOS Detector	\$47,988	\$48,138	\$48,216
2.1	Magnets: Steel & Coils	7,621	7,595	7,595
2.2	Scintillator Detector Fabrication	19,525	19,517	19,517
2.3	Electronics, DAQ & Database	9,173	9,134	9,165
2.4	Far Detector Installation	4,581	4,577	4,577
2.5	Near Detector Installation	5,361	5,529	5,576
2.6	MINOS Project Management	1,727	1,787	1,787
3	Project Support	\$19,906	\$19,900	\$19,900
3.1	NuMI Conceptual Design	1,934	1,928	1,928
3.2	MINOS Detector R&D	1,768	1,768	1,768
3.3	MINOS Cavern	14,527	14,527	14,527
3.4	Soudan/MINOS Operating	1,677	1,677	1,677
	Contingency	\$2,899		
	Total NuMI Other Project Costs	\$70,793	\$68,038	\$68,116
	UK In-Kind Contribution	(\$4,835)	(\$4,835)	(\$4,835)
	Minnesota Preconstruction Funds	(758)	(758)	(758)
	Minnesota Construction Funds	(3,000)	(3,000)	(3,000)
	Total US Funds	\$62,200	\$59,445	\$59,523
	Total Project Cost	\$171,368	\$167,352	\$167,748

OPC - Obligations =
\$2677

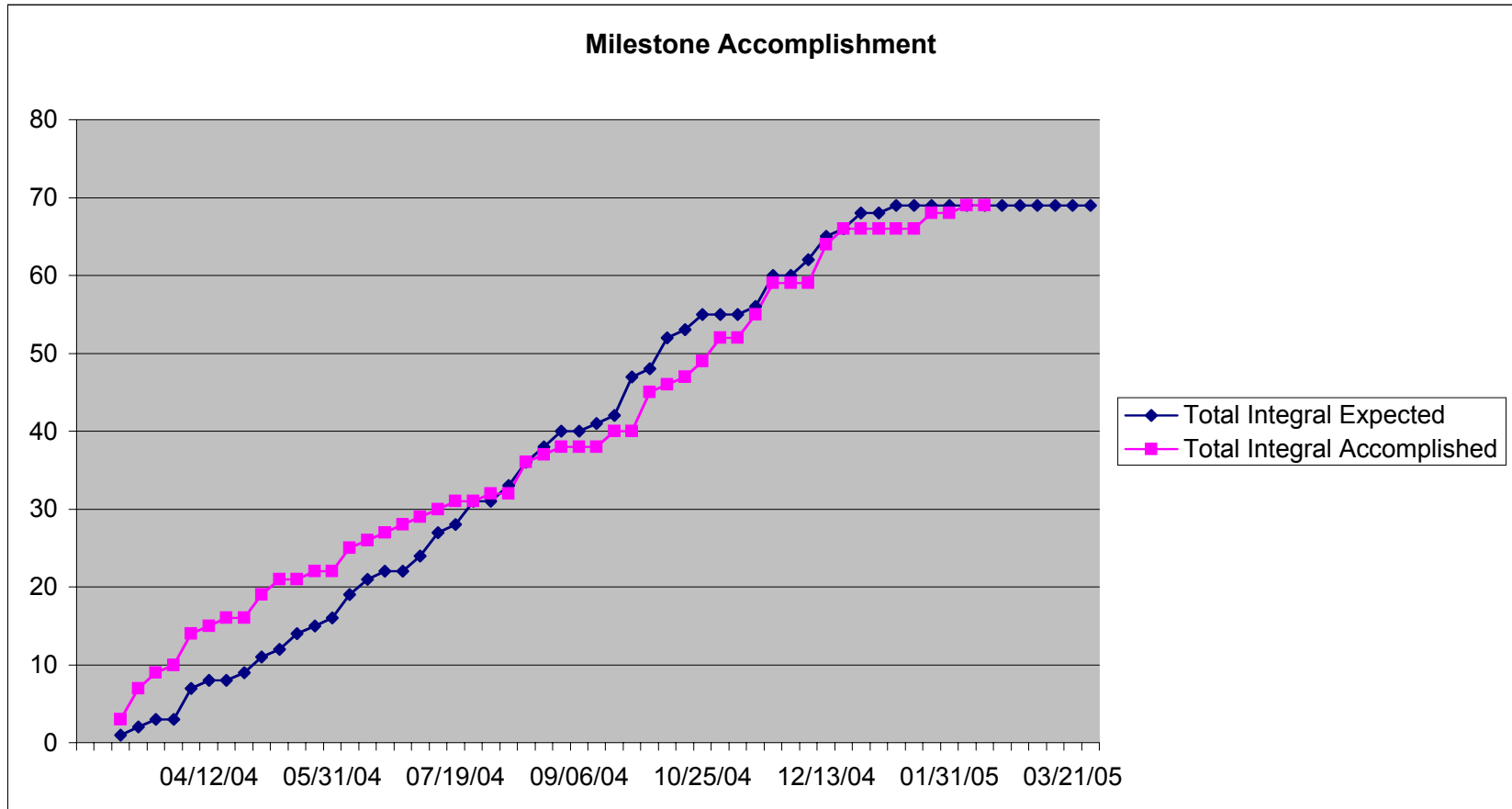


Schedule Summary

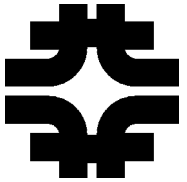




The Plunkett Plot



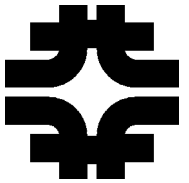
All future projects should do this from the beginning;
NuMI had a total of 343; last 69 plotted here



Conclusion

- We have designed and built and will operate a safe facility
- We have a single routine punch list item (hookup of a chiller underground)
- We met our commissioning goals
- The labs operating divisions and sections are staffed for and knowledgeable about the NuMI facilities and beam
- The MINOS detector is operated by the MINOS Collaboration; an MOU between the collaboration and Fermilab organizations is underdevelopment
- The University of Minnesota smoothly runs the Soudan Laboratory under an MOU with Fermilab
- Final project closeout will occur in the summer, including financial closeouts and procedural documentation

We believe we are ready to begin operations!



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